The Development of Road Traffic Simulator (PIMTRACS) by PIM

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Abstract The most noticeable characteristics of road traffic system is its parallelism and modularity. The first thing we have to take into consideration in developping road traffic system simulator is what types of computer system and modelling concept are suitable for that. We have so far developped TRACSS (Road Traffic Control System Simulator) along the above-mentioned basic direction. Recently, however, we have come to know more pertinent computer PIM has been developped in Japan and USA. PIM stand for Parallel Inference Machine. It was developed under the close cooperation of Yasukawa Electric Corporation (Japan) and Flavors Technology Inc.(USA). It has the quite innovative architecture and excellent GUI environment.

The paper describes how exquisitely the parallel processing of constituent elements of road traffic system model(PIMTRACS) has been done, and improvement of processing speed and the reasonable processing of inconsistent simultanous competitive events have been realized. In more concrete expression, the road traffic model has been totally described, having been divided into the vehicle control subsystem, road control subsystem, road signal control subsystem, output control subsystem, random number and others processing subsystem. The regions for vehicles, roads, and road signals have been provided and each individual vehicles have been described in parallel. The special contrivance has been added to the setting-up of facility region, to the behavior description of vehicles generation, their runs, their disappearance, etc.

After the typical model has been built, actual field data as to the particular intersection have been gathered, and its simulation was executed. The simulation results were compared with the actual data and the model validity has been verified. The simulation results were collated with the well-known traffic flow theory, and we have found that the simulation results conform well to the theory.

1. INTRODUCTION

In our modern social lives, the vehicles assumes an important responsibility in various fields such as commuters/ freight transportation, and the related demmand is increasing rapidly. The road traffic network in change of traffic flow is also growing day by day.

A recent trend seems to be the revision for road facilities and the increase of the number of lanes, in other words, the broadening of road itself.

The problem, especially in Japan is the rapid increase of population in urban area and the insufficient supply of lane in road construction, which causes the chronic traffic congestion there.

Various studies have been conducted to solve these problems. The computer simulation is a methodology. But the traffic system itself is very complicated and the duplicated characteristics of continuity and discreteness of road traffics have kept refusing the reasonable solution even if the advanced technology of computer simulation has been applied. One of the difficult problems is the existence of many independent entities such as vehicles, pedestrians, roads, signal facilities and the like. The conventional computers were not always appropriate to describe such a model. The modelling by use of priority description was one of the temporary expedient, but it was not complete.

One of the countermeasure we took was the utilization of PIM. PIM is substantially a parallel computer and suitable for handling parallel events. PIMTRACS is an acronym for the Traffic Simulation System by PIM. It has enabled the reasonable representation of road traffics and simulation execution. The study describes the actual modelling and simulation through PIMTRACS.

2. A BRIEFING OF PIM

The scale grow of system and the variety increase of users'

needs has promoted the scale increase of application software of computer systems, and it has given birth to the decline of its productivity and maintenancability.
PIM is an innovative parallel processing machine developed in close cooperation of Yasukawa Electric Corporation(Japan) and Flavors Technology Inc.(USA). It has quite an innovative architecture and GUI(Graphical User Interface) environment. The use of PIM provides quite a new software engineering methodology, and improves largely the productivity and maintenancability of application software.
The main features of PIM are as follows.

- Reduction of response time by way of parallel synchronous processing
- Effective support of system design and maintenance under the integrated development environment
- Free program modification in a online environment
- Easy programming through natural language.
- Flexible extention of computer system according to the application system scale

PIM composes the system through units called 'tile', which simplifies the modularization of system. Thus PIM enables quite a new system comfigulation and is considered an ideal computer system equipped with compact and excellent facilities, high reliabilities, productivities and maintenancability.

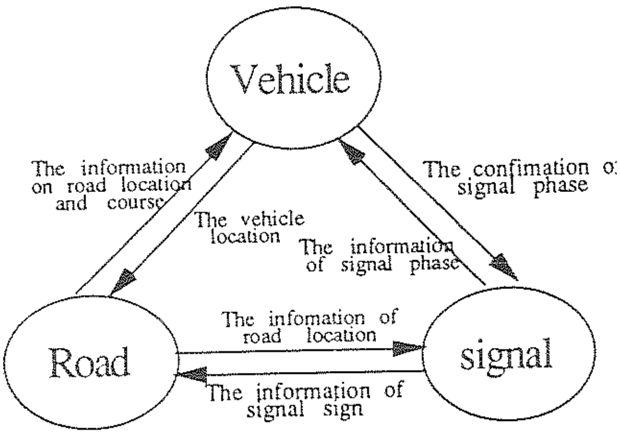


Fig1. A concept of PIMTRACS

3. THE OUTLINE OF PIMTRACS

In PIMTRACS a model is composed as shown in Fig1., describing each region and vehicle in parallel.
Many road traffic simulators have so far been developed, but in most of procedure-oriented simulators, one among the numerous independent entities was taken up and processed and the other entities were represented as those which gave interruption to the main entity.
Some computers had parallel processing capability, but in general most of them required large scale facilities like workstation or supercomputer and rejected the easy treatment.
Our Macintosh PIM is of personal computer environment, and can be of use if it is equipped with hardware facilities over a certain standard. It can be operated with by far smaller scale installation with parallel processing capability. It is considered to be more effective in simulation of road traffic system.
The road traffic simulation model in PIMTRACS is composed of six modules as shown in Fig.2.

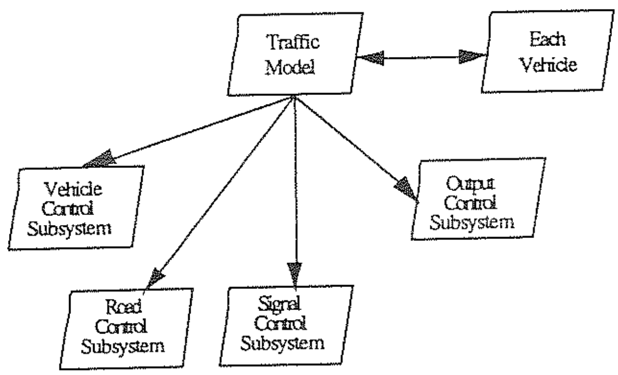


Fig2 PIMTRACS overall comfiguration

4. VEHICLE MODELLING

Each vehicle moves independently in our model. Its model is devided into two. One of them is the running section which describes the running behaviors of vehicle and the other is the output section which monitors the vehicles movement.
The running section sends the related data to the output

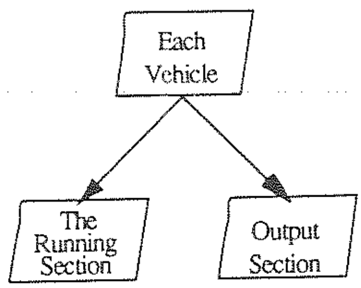


Fig3 The vehicle modelling

section every simulation cycle, which has enabled the easier simulation execution.

4.1 The Running Section

In running section a tile was assigned to each vehicle and a tile described the vehicle behavior. The description of vehicle behavior is illustrated in Fig 4.

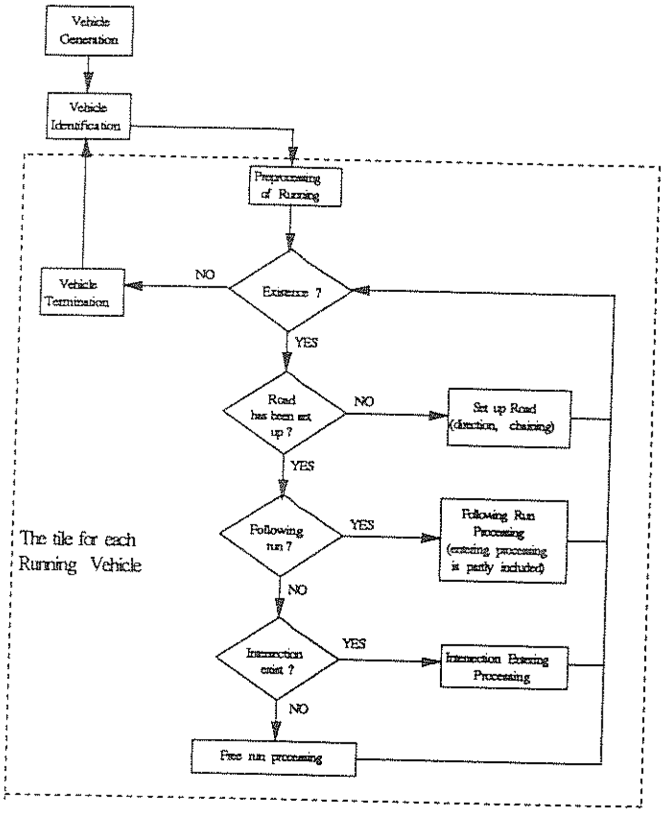


Fig.4 The description of vehicle behavior

(a)Vehicle generation/germination

This tile itself does not set up the vehicle is generated on the road according to the derection of vehicle generation. The vehicle generation and vehicle control. When a vehicle finishes running and gets out of the set-up road, an indication of vehicle disappearance is given form the road and a vehicle is terminated.

(b)Free run

Free running vehicle is a vehicle which is not given any influence from the vehicle running ahead.

(c)Following run

If a vehicle runs in accordance with the speed of a vehicle running ahead, it is called following run.

(d)Signal effected run

In free run, if the distance up to the signal is shorter than the braking distance, the vehicle runs in consideration of signal phase, its own speed and direction.

(e)Acceleration

The study gives no consideration to the various performance of vehicle itself. Thus only the minimum consideration has been given to the acceleration and deceleration of vehicle run in the simulation.

(f)Deceleration

In general it is said that "The braking distance of a vehicle is proportional to the square of running speed" In our simulation model we followed this principle basically.

4.2 Output Section

In output section, each vehicle data is updated each simulation cycle, and these data are sent to the statistical terms(tile), among which the necessary items are sent to the output section. In our siulation model, the inflow and outflow times to the road can be recorded.

5. VEHICLE CONTROL SUBSYSTEM

The control of vehicles on the overall roads and signal phases are carried out in the vehicle control subsystem as a whole. The simulation environment of vehicles are set up with the assignment of tile numerical values as shown in Fig.5.

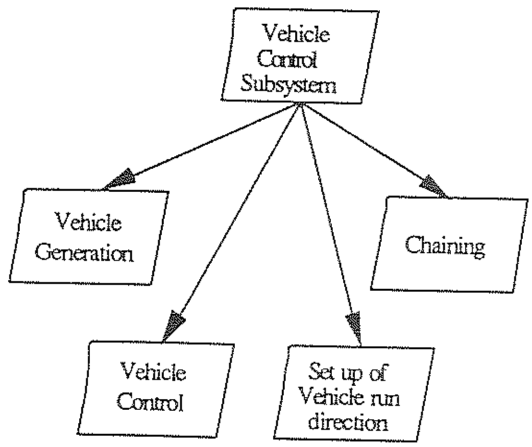


Fig.5 The Vehicle Control Subsystem Configuration

(a)Vehicle generation

This is a tile giving a direction of vehicle generation to the road on which vehicle generation is capable. In our simulation model a random numbler generation method can be used. A tile can be applied to the vehicle generation of up to 7 roads.

(b)Vehicle control

Vehicle control receives the direction from Vehicle generation sent to each road and processes the transmission of data to the vehicles not used at present. This time plays a roll of giving and receiving he data to and from each vehicle, and this helps to know the existence of each vehicle. One tile can control as many as 8 vehicles.

(c)The setting up of direction

This tile gives direction to each generated vehicle as follows. When a road branches into two, the tile gives the random number to decide which road to take, and otherwise the numerical data to proceed forward.

(d)Chaining

When a vehicle flows in each road, it gives infomation to the road that it is the most recent vehicle and the road gives information to the inflow vehicle the number of preceding car which enables the recognition of the preceding car in following run. One tile can treat as meny as 4 merging roads.

6. ROAD CONTROL SUBSYSTEM

The study has changed its standpoint from individual vehicle-oriented modelling to the vehicle existence road location-oriented. Thus all the roads have been divided into road sections separated by intersections and intersections themselves, and have given particular numbers by each direction and lane. The first place of the number is the lane number, and the other places are the number of the road itself. Fig.6 shows an example.

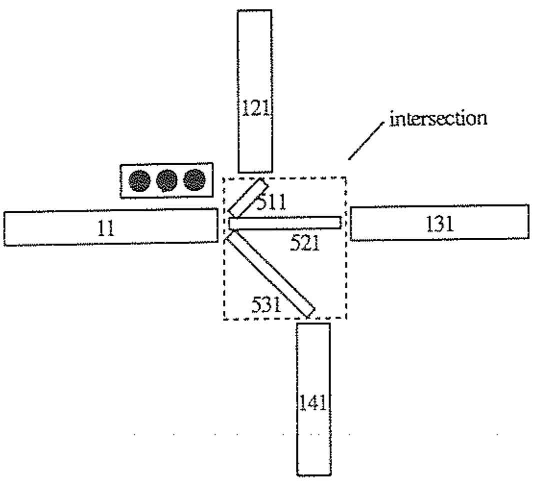


Fig.6 The representation of roads and an intersection

A road is divided into sections of 5 meters unit. This formation has realized the flexibility of road description and contributed to the generalization of simulation system.

The road managemet subsystem is illustrated if Fig.7

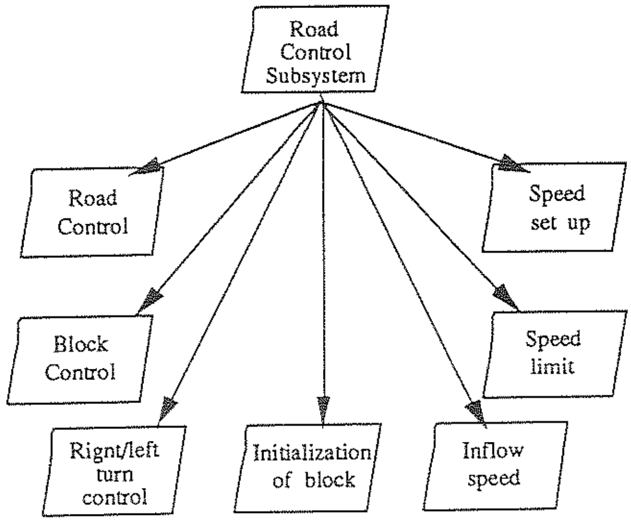


Fig.7 The System Configuration of Road Control Subsystem

(a)Road control

This tile connects the lanes on the road and gives the road number information of next entrance to the running vehicle

(b)Block control

This is a tile which executes the lane connection of each road and gives the information on maximum value (namely, the length of the block) of the block of next entrance.

The number 0 to 99 can be assigned to the block. In case that the present road does net extend to the next, -1 is set up, which terminates the vehicle automatically.

(c)Right turn control

A vehicle entering the intersection generally proceeds straight, turns left or right. In case of straght proceeding or left turn, a vehicle can follow the singal phase and does nto have to worry about oncoming cars, but right turn vehicle has to watch them. This tile is a special tile to assure safe right turn. We provided SF(street front) which is a part of a street and has a meaning that if there is no cars in the opposit SF, the right turn is possible. Here SF was set up to 5 blocks (25 meters).

(d)Block initialization

This is a tile which is used for setting up the length of a road where vehicles are generated. This tile is basically the same with block control, but differs from block control in that there is no vehicles that have been generated, so it is not capable to set up the road on which the particular vehicle is running at present.

(e)Speed set up

This is a tile where initial speed information of a vehicle is given in terms of a road where the vehicle is generated. In this study a default value is used, but it has been designed to be able to choose a random number speed.

(f)Speed limit

This is a tile where legal speed limit is set up.

(g)Inflow speed

This is a tile where a safe speed limit is given at the time when a vehicle enters in the different road section. For example, 15 km/h for right turn and 20km/h for left turn.

7.SIGNAL CONTROL SUBSYSTEM

In this study the fixed cycle signal control subsystem has been adopted.

(a)Signal control

This is a tile which gives signal information to vehicles. This is designed to be able to expand to vehicle-actuated signal control subsystem.

8.OUTPUT CONTROL SUBSYSTEM

4 terms has been selected to offer the informations on traffic flow and traffic conjestion as shown in Fig.8

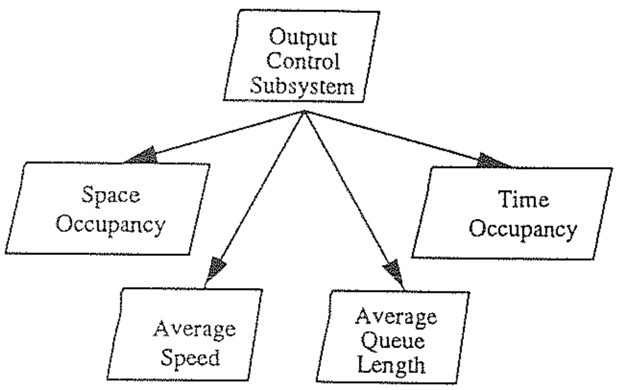


Fig.8 Output Control Subsystem

(a)Sectional average speed

Usually 2 kinds of average speeds are used, one is the time mean speed and the other is the space mean speed. In the study the space mean speed has been adopted. The computation algorithm is as follows.

Sectional average speed = section length / (inflow time - outflow time)

(b)Average waiting time

The waiting time is an important measure to evaluate a signal control subsystem.

Our computation algorithm is as follows. When a vehicle halts, namely the speed comes down to zero,

1 is added to the waiting line counter of the road. On the other hand, when a vehicle start to move, namely start to run at the speed higher than zero, then 1 is added to the waiting line minus counter. This counting is executed every second and used to calculate the waiting time of vehicles and that of a road by summing them up.

(c)Occupancy

There are two kinds of occupancies, that is the time occupancy and the space occupancy.

1)time occupancy (Ot)

Ot is the time percentage of vehicles which occupied the road cut phase (ti) over the time the vehicle occupied the road (T).

$$O_t = \frac{1}{T} \sum_i t_i \times 100 \ (\%)$$

In our study the calculation is executed every second and accumulated to get Ot.

2)Space occupancy(Os)

Space occupancy is the percentage of vehicles which occupy a road section of fixed length at an time instant over total length of the section (S).

$$O_s = \frac{1}{S} \sum_i l_i \times 100 \ (\%)$$

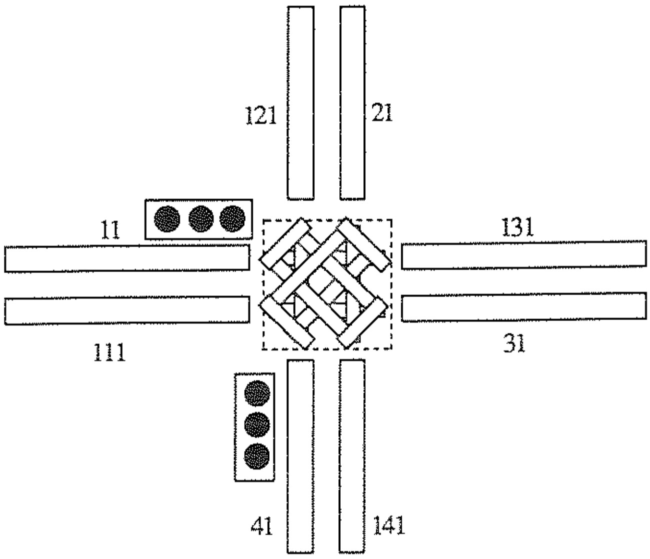
9.SIMULATION DISPLAY

The study aims at the animated display of simulation by use of GUI facilities and vesualization of simulation process and simulation results.

The road network is composed of intersectional element illustrated in Fig9.

Intersection are composed of 6 objects(entities) and the road network is organized to connect these intersections. A vehicle is displayed in 8 colours to bo able to recognize the vehicle and its properties at a glance.

PIM has PICT function, by which sinal phase is displayed. They are changeable according to the numerical values issued from a tile of signal control subsystem The simula-



Outflow	Inter-section	Inflow
11	511	121
11	521	131
11	531	141
21	541	131
21	551	141
21	561	111
31	571	141
31	581	111
31	591	121
41	601	111
41	611	121
41	621	131

Fig.9 The Model Design of Intersection of PIMTRACS

tion output can be numerical and obtained from the global function calculation.

10.THE CONCLUSION

The design concept is very important in the development of road traffic system simulator. It is strongly influenced by the computer hardware performance. PIMTRACS has been developed based on the advanced technology of PIM, which has given birth to a high performance simulation system for the road traffic control system.

11.ACKNOWLEDGEMENTS

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